

Chapter 2

Weapons-Usable Fissile Materials Long-Term Storage and Disposition Alternatives

2.1 DEVELOPMENT OF ALTERNATIVES

Alternatives analyzed in this PEIS were determined through a screening evaluation process in which a comprehensive set of screening criteria were used. From this process, reasonable alternatives for the following were identified:

- The strategy for long-term storage of weapons-usable Pu and HEU, including nonsurplus Pu and HEU, and surplus Pu and HEU pending disposition
- The strategy and technology for disposition of surplus weapons-usable Pu

In addition, a list of candidate sites for long-term storage of weapons-usable Pu and HEU was developed based on site-selection criteria established previously. The site selection process is described in Section 2.1.3. These reasonable alternatives and candidate sites are analyzed in this PEIS as part of the input for DOE's decisionmaking on the storage and disposition of weapons-usable fissile materials.

2.1.1 SCREENING CRITERIA

To determine reasonable alternatives for evaluation in this PEIS, DOE developed, for both long-term storage and disposition, screening criteria based on the policy objectives articulated in the President's *Nonproliferation and Export Control Policy* of September 1993 and the January 1994 *Joint Statement by the President of the Russian Federation and the President of the United States of America on Nonproliferation of Weapons of Mass Destruction and the Means of Their Delivery* (see Appendix A), as well as the analytical framework established by NAS in its 1994 report, *Management and Disposition of Excess Weapons Plutonium* study. Based on input from the public during the scoping process, the screening criteria were expanded and used for selecting reasonable alternatives. Descriptions of the screening criteria used for long-term storage and disposition alternatives are given in Sections 2.1.3 and 2.1.4, respectively.

2.1.2 SCREENING EVALUATION PROCESS

The screening evaluation was conducted by a committee of five DOE technical experts, DOE officials assisted by advisors from the National Laboratories, and other support staff. Based on a review of the NAS report, prior DOE-sponsored work on HLW disposal, and input from the public obtained during the scoping process, the screening committee identified an extensive set of options and developed potential disqualifiers for both long-term storage and disposition options. Each option represented a storage or disposition strategy that might be implemented in a systematic, cradle-to-grave manner. There were 5 long-term storage options, 37 Pu disposition options, 9 HEU disposition options, and 8 U-233 disposition options. As previously identified in Chapter 1, the disposition of surplus HEU and disposition of U-233 are not within the scope of this Storage and Disposition PEIS; disposition of surplus HEU is addressed in the HEU Final EIS and U-233 disposition will be addressed at the time it is proposed by DOE and found to be ready for decision.

The screening committee evaluated each option against potential disqualifiers to determine if any options had a "fatal flaw" in one or more of the screening criteria. For example, inability to meet the Stored Weapons Standard or the Spent Fuel Standard was considered a fatal flaw that resulted in the disqualification of an option. Options that survived this process were then ranked. Each option was rated high, medium, or low against each screening

criterion, relative to other options. This ranking process eliminated options that were rated low for multiple criteria or were clearly dominated by similar, more attractive options in the same category. Options that survived the ranking process emerged as reasonable alternatives for detailed evaluation in the Storage and Disposition PEIS. Details of the screening evaluation process can be found in the *Summary Report of the Screening Process* (DOE/MD-0002). After considering public comment on the Draft PEIS, as well as other public comments and internal DOE review following the Draft PEIS, DOE has for some of the disposition alternatives clarified and expanded explanations of the screening rationale and has added DoD's Manzano WSA Facility as a storage facility under consideration. A description of alternatives considered but eliminated for further analysis, along with reasons for elimination, is given in Section 2.1.3 for long-term storage and Section 2.1.4 for Pu disposition.

2.1.3 REASONABLE ALTERNATIVES FOR LONG-TERM STORAGE OF WEAPONS-USABLE FISSILE MATERIALS

Screening Criteria for Long-Term Storage Options

Resistance to Theft and Diversion by Unauthorized Parties. The site and facility must be capable of providing comprehensive protection and control of weapons-usable fissile materials (that is, meet the Stored Weapons Standard).

Technical Viability. There should be a high degree of confidence that the facility and site infrastructure can provide storage of nuclear components and materials for up to 50 years.

Environment, Safety and Health (ES&H) Compliance. High standards of public and worker health and safety and environmental protection must be met, and significant additional ES&H burdens should not be created.

Cost-Effectiveness. Long-term storage should be accomplished in a cost-effective manner and should be compatible with reasonable disposition alternatives.

Timeliness. Long-term storage should be implemented in a timely manner.

Fosters Progress and Cooperation With Russia and Other Countries. A facility must accommodate international inspections for surplus material in unclassified forms and must establish appropriate standards for storage and protection of international nuclear material inventories.

Public and Institutional Acceptance. An alternative should be able to muster a broad and sustainable consensus on the manner in which long-term storage is accomplished.

Results of the Screening Process: Reasonable Alternatives for Long-Term Storage

Options that were not disqualified or eliminated through the use of the screening criteria emerged from the screening process as reasonable options for further evaluation. As a result of the screening process, two options were identified as reasonable:

- Upgrade of storage facilities to make them suitable for long-term storage (upgrade existing storage capability at more than one site)
- Consolidation of the weapons-usable fissile materials at DOE sites (consolidate or collocate storage at one or two DOE sites)

Both options assumed that all nonsurplus HEU and surplus HEU pending disposition were located at ORR before initiating any action under this PEIS. The scope of the first option, upgrade existing storage capability

(referred to in the PEIS as Upgrade at Multiple Sites Alternative or Upgrade Alternative), has been expanded to include the possibility of upgrading through new construction where existing facilities cannot be economically modified to meet requirements and to account for the relocation of RFETS and/or LANL Pu to one or more Pu storage sites. The second option, consolidate storage at DOE sites, has been modified to separately address two alternative approaches: the Consolidation of Pu Alternative, and the Collocation of Pu and HEU Alternative. For each alternative (Upgrade at Multiple Sites Alternative, Consolidation of Pu Alternative, and the Collocation of Pu and HEU Alternative), a subalternative has also been added that would exclude the strategic reserve and weapons R&D material covered by the Stockpile Stewardship and Management PEIS. Finally, a Preferred Alternative was developed, representing a combination of alternatives. The PEIS alternatives are further described.

Upgrade at Multiple Sites Alternative: Modify Existing *and/or* Construct New Facilities at More Than One Site for Continued Storage of Plutonium and Highly Enriched Uranium; Relocate Rocky Flats Environmental Technology Site and Los Alamos National Laboratory Plutonium to Another Plutonium Storage Site. Under this alternative, DOE would modify certain existing facilities and/or build new facilities, depending on individual site requirements for meeting updated DOE standards for nuclear material storage facilities. The facilities would be designed to operate for up to 50 years. Pu material currently stored at Hanford, INEL, Pantex, and SRS would remain at those sites. Pu currently in storage at RFETS and LANL would be moved to a single long-term storage site or distributed for long-term storage at more than one site. HEU material stored at ORR would remain at that site in modified facilities.

Consolidation of Plutonium Alternative: Construct New Facility *or* Construct New and Modify Existing Facilities at One Site for all Plutonium Materials; Maintain (and Modify as Necessary) Existing Highly Enriched Uranium Facilities at Oak Ridge Reservation. Under this alternative, a new consolidated Pu storage facility would be constructed alone or with modified existing facilities to store current and future DOE weapons-usable Pu inventories. Pu would be removed from existing storage facilities at Hanford, INEL, Pantex, SRS, RFETS, and LANL and transported to the consolidated storage facility. The facility would be designed to provide safe, secure, long-term storage of both nonsurplus Pu and surplus Pu (pending disposition) for up to 50 years. HEU material stored at ORR would remain at that site. DOE would maintain and, as necessary, modify and upgrade the ORR facilities to ensure continued safe, secure storage.

Collocation of Plutonium and Highly Enriched Uranium Alternative: Construct New Facility *or* Construct New and Modify or Maintain Existing Facilities at One Site for all Plutonium and Highly Enriched Uranium Materials. Under this alternative, a new consolidated Pu storage facility would be collocated with new or existing HEU facilities to store current and future DOE weapons-usable fissile material inventories. The facilities would be responsible for storing Pu as well as HEU. Pu would be moved from existing storage facilities at Hanford, INEL, Pantex, SRS, RFETS, and LANL. HEU would either stay at ORR, should ORR be selected, or be moved to the collocated storage facility. The facility would be designed to provide safe, secure, long-term storage for up to 50 years.

Preferred Alternative. Under the Preferred Alternative, existing facilities would be upgraded at Pantex, ORR,¹ and SRS. RFETS Pu pits would be relocated to Pantex, and RFETS surplus non-pit Pu materials would be relocated to SRS. Current storage would continue (No Action) at Hanford, INEL, and LANL for surplus Pu, pending disposition. Strategic Reserve pits would be stored at Pantex in accordance with the Preferred Alternative in the Stockpile Stewardship and Management PEIS. No Action would be taken at NTS; Pu storage would not be added to NTS, consistent with the site's current mission.

Figure 2.1.3-1 depicts the conceptual structure of the long-term storage alternatives and the Preferred Alternative for storage analyzed in this PEIS. Under each long-term storage alternative and the No Action

¹ DOE may subsequently propose to construct new HEU storage facilities at ORR; any such proposal would be assessed in subsequent site-specific NEPA documentation.

Alternative, Figure 2.1.3–1 describes the action that would be taken at the various candidate sites and locations for these materials.² For the No Action Alternative and upgrade, consolidation and collocation long-term storage alternatives, this PEIS analyzes the impact of storing all weapons-usable fissile materials. Under these alternatives, this PEIS also analyzes the impacts of storing weapons-usable fissile materials excluding those covered under the Stockpile Stewardship and Management PEIS (strategic reserves and some weapons R&D materials). [Text deleted.]

Candidate Sites for Long-Term Storage Alternatives

Six locations (Hanford, NTS, INEL, Pantex, ORR, and SRS) are being considered as candidate sites for the long-term storage of weapons-usable fissile materials. Each site is being considered for the location of upgraded, consolidated, or collocated storage facilities.

Site Screening Process

Concurrent with the publication of the NOI to prepare a PEIS for Reconfiguration of the Nuclear Weapons Complex in the *Federal Register* (56 FR 5590) on February 11, 1991, a *Notice of Availability of an Invitation for Site Proposals for the Nuclear Weapons Complex Reconfiguration Site* was also published (56 FR 5595). The invitation solicited proposals for consideration of non-DOE sites and listed five DOE sites that met the initial screening criteria (Hanford, INEL, Pantex, ORR, and SRS). No additional locations were identified as a result of this invitation.

The five initial sites were evaluated against the following siting criteria: (1) density and distribution of population, (2) ES&H, (3) socioeconomics, (4) site availability, (5) transportation, and (6) site flexibility. All sites were found by the Site Evaluation Panel to be fully qualified.

There have been significant changes in the world since publication of the *Nuclear Weapons Complex Reconfiguration Study* in January 1991, especially with regard to projected future requirements of the United States' nuclear weapons stockpile. As a result, the study no longer provides a suitable framework for determining the appropriate configuration of the future Nuclear Weapons Complex. Therefore, DOE decided to separate the Reconfiguration PEIS into two PEISs: a TSR PEIS and a Stockpile Stewardship and Management PEIS.

A Revised NOI to prepare a Reconfiguration PEIS was published in the *Federal Register* (58 FR 39528) on July 23, 1993. In this notice, DOE eliminated Hanford from further consideration as a candidate site, because all nuclear weapons production functions at that location had been terminated and the site was dedicated to environmental and waste management activities. NTS was evaluated using the siting criteria described above and was determined to be a reasonable site alternative for new tritium supply and recycling facilities. The resulting five sites—NTS, INEL, Pantex, ORR, and SRS—were evaluated in the TSR PEIS.

The long-term storage mission is a portion of the proposed action considered under the original reconfiguration proposal. Thus, sites meeting criteria for reconfiguration are considered reasonable for the long-term storage mission. Since the five TSR sites meet these criteria, they are being considered for long-term storage of weapons-usable fissile materials. In addition, Hanford is considered a reasonable site for the following reasons:

- It satisfies the original reconfiguration criteria
- Long-term storage is consistent with its current mission

² As of September 1994, LLNL stored 0.3 t (0.3 tons) of Pu, which are primarily R&D and operational feedstock materials not surplus to government needs. Adequate storage facilities for this material currently exist at LLNL; consequently, none of the Pu stored at LLNL falls within the scope of this Storage and Disposition PEIS.

- It has the infrastructure to support a long-term storage mission

The resulting sites—Hanford, NTS, INEL, Pantex, ORR, and SRS—are analyzed in the PEIS.

Long-Term Storage Alternatives Considered But Eliminated from Further Analysis

As a result of the screening process, two long-term storage options were eliminated: the utilization of existing facilities at non-DOE domestic sites for storage of non-pit Pu forms, and the utilization of non-domestic sites. The utilization of existing facilities at non-DOE sites for long-term storage as an option was rated but eliminated from further consideration. The Pantex EIS analyzes DoD's Manzano WSA near Albuquerque, NM, as a candidate non-DOE domestic site for temporary storage of Pu pits (58 FR 39528). [Text deleted.]

As in the case of temporary pit storage, the materials to be placed in long-term storage include Pu pits. However, they also include oxides and other dispersible material forms that may require treatment and repackaging not needed for pits. There are ES&H concerns associated with locating these operations in proximity to the metropolitan Albuquerque area. Furthermore, there is insufficient land area available to construct the necessary direct support facilities needed for analysis, repackaging, accounting, and waste management. Therefore, the Manzano WSA was considered in the Draft PEIS but eliminated as a reasonable alternative primarily because Manzano WSA could not accommodate storage of both pit and non-pit materials.

Since the issuance of the Draft PEIS, DOE has developed a Preferred Alternative for storage that would separate storage of most Pu pits from storage of non-pit Pu material. Specifically, the Preferred Alternative would store Pu pits from Pantex and RFETS at Pantex, and would store non-pit Pu at SRS, Hanford, and INEL. Since DOE's Preferred Alternative would separately locate storage of pits and non-pit Pu from RFETS, the option to store pits at Manzano WSA no longer appears unreasonable. Therefore, DOE has added Appendix P to the Final PEIS, which discusses potential storage of Pantex and RFETS pits at Manzano WSA.

For a number of reasons, the Preferred Alternative would store the pits from Pantex and RFETS at Pantex, rather than Manzano WSA. Pantex is the proposed site for interim storage of pits under the Preferred Alternative in the Pantex EIS.³ The majority of the pits that require storage are surplus to U.S. defense needs and are already located at Pantex. The number of pits that would be relocated from RFETS would be small by comparison. Since the majority of pits are already in storage at Pantex, it would be prudent for DOE to consolidate all pits there for storage. Assembly and disassembly operations would continue at Pantex even if pit storage did not occur there. Selecting Manzano WSA would require DOE to create another site where Pu would be located with the risk of contamination and the associated costs for site infrastructure and security. In addition, other missions that could be added to Pantex (for example, pit disassembly/conversion or MOX fuel fabrication) could not be added to Manzano.

Storage at Manzano WSA would involve the transportation risk of moving these materials from Pantex to Manzano WSA. Furthermore, two shipment campaigns would be required for disposition for most of the pits (those already at Pantex) if Manzano WSA were chosen, whereas only one shipment campaign of those same pits would be required if the pits were stored at Pantex. For the Manzano case, pits at Pantex would require relocation to Manzano and then a second shipment campaign to a disposition site. Leaving the pits in storage at Pantex would result in only one shipment campaign from Pantex to the disposition site.⁴

The utilization of non-domestic sites for long-term storage was proposed, but was eliminated from further consideration because it was not able to address all of the long-term storage requirements. These requirements

³ The disposition of these surplus pits would begin within the next 10 years and would be completed within the next 25 years. The time period required for the storage of the pits is therefore close to that considered in the Pantex EIS for pit storage and the reasons for not using Manzano WSA are the same.

⁴ Two shipment campaigns of pits would be required for those pits currently stored at RFETS for both Pantex and Manzano.

include the storage of the materials set aside as strategic reserve for defense purposes, which are not appropriate to locate outside the United States. This option was disqualified in the screening process for non-strategic reserve material as well, because the risk of theft or diversion by unauthorized parties would be greater than those involved in the utilization of domestic sites. Safeguard and security of nuclear materials are also enhanced by the domestic law enforcement infrastructure, which would not be easily coordinated outside the United States. Figure 2.1.3–2 shows the long-term storage options that were considered and rated based on the seven screening criteria and the principal reasons for disqualification or elimination. The Preferred Alternative for storage at each DOE site was selected from among these storage options.

STORAGE OPTIONS

NO ACTION	Baseline
UPGRADE EXISTING INTERIM STORAGE FACILITIES	Reasonable
CONSOLIDATE STORAGE AT DOE SITES	Reasonable
UTILIZE FACILITIES AT NON-DOE DOMESTIC SITES	Eliminated (Cost-Effectiveness, ES&H)
UTILIZE NON-DOMESTIC SITES	Disqualified (Higher Safeguard and Security Risks)

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Figure 2.1.3–2. Results of the Screening Process—Long-Term Storage Options.

2.1.4 REASONABLE ALTERNATIVES FOR THE DISPOSITION OF SURPLUS PLUTONIUM

Screening Criteria for Disposition Options

Resistance to Theft and Diversion by Unauthorized Parties. Each step in the disposition process must be capable of providing for comprehensive protection and control of weapons-usable fissile materials.

Resistance to Retrieval, Extraction, and Reuse by Host Nation. The surplus material must be made highly resistant to potential use in weapons to reduce reliance on institutional controls and demonstrate that the arms reductions will not be easily reversed.

Technical Viability. There should be a high degree of confidence that the alternative will be technically successful.

Environmental, Safety and Health Compliance. High standards of public and worker health and safety, and environmental protection must be met, and significant additional ES&H burdens should not be created.

Cost-Effectiveness. Disposition should be accomplished in a cost-effective manner and be compatible with reasonable long-term storage alternatives.

Timeliness. There is an urgent need to begin Pu disposition and to minimize the time period that surplus fissile materials remain in weapons-usable form.

Fosters Progress and Cooperation With Russia and Other Countries. The alternative must establish appropriate standards for the disposition of surplus weapons-usable fissile material inventories and support negotiations for bilateral or multilateral reductions in these materials, and each step in the disposition process must allow international inspections.

Public and Institutional Acceptance. An alternative should be able to muster a broad and sustainable consensus on the manner in which disposition is accomplished.

Additional Benefits. The ability to leverage government investments for disposition of surplus materials to contribute to other national or international initiatives should be considered.

Results of the Screening Process: Reasonable Alternatives for Surplus Plutonium Disposition

As a result of the screening process for surplus Pu disposition, three alternative categories consisting of nine alternatives are considered reasonable. The alternative categories for further evaluation are the deep borehole category, the immobilization category, and the reactor category:

Deep Borehole Category. Within this category, surplus weapons-usable Pu would be emplaced in deep boreholes drilled several kilometers below the water table into ancient, geologically stable rock formations. The deep boreholes would be sealed to isolate the Pu from the environment.

Two Deep Borehole Alternatives were analyzed for this PEIS:

- **Direct Disposition Alternative**—direct emplacement of canisters containing Pu forms that have not been immobilized
- **Immobilized Disposition Alternative**—Pu immobilized in ceramic pellets (without the addition of high-energy, gamma-emitting radionuclides) would be emplaced in a borehole as part of a grout-pellet mixture

In the first borehole alternative, surplus weapons-usable Pu would be encapsulated directly in suitable canisters without any immobilization processing of Pu material and the canisters would be placed in a deep borehole. The deep borehole would then be plugged after completion of the emplacement. In the second deep borehole alternative, surplus weapons-usable Pu would be converted to an immobilized ceramic form. The immobilized Pu form then would be directly emplaced in a deep borehole without encapsulation in canisters, and the deep borehole would be plugged after completion of the emplacement. Under both alternatives, emplacement in a deep borehole would provide a geologic barrier to proliferation and Pu could not be recovered by the host nation undetected. Therefore, the Pu would not need to be mixed with HLW or other radioactive materials to provide a radiation barrier to recovery.

Immobilization Category. Within this category, surplus Pu would be immobilized in an acceptable matrix to create a chemically stable form for disposal. The immobilized material would be placed in lag storage prior to transfer to a repository constructed pursuant to the *Nuclear Waste Policy Act* (NWPA), as amended (see discussion in Section 2.4). The immobilized Pu would contain HLW or a radioactive isotope to create a radiation field that enhances proliferation resistance to meet the Spent Fuel Standard.

Three Immobilization Alternatives were included in this PEIS:

- **Vitrification Alternative.** This alternative would consist of building a new facility or modifying existing facilities to produce a glass waste form that embeds Pu and radioisotopes within the glass form. This PEIS analyzes the impacts associated with building and operating a new facility at any of six DOE sites (Hanford, NTS, INEL, Pantex, ORR, and SRS). As an example of a technology variant at existing facilities, Appendix O of this PEIS describes the can-in-canister variant at the DWPF at SRS.
- **Ceramic Immobilization Alternative.** This alternative would consist of building a new facility or modifying existing facilities to produce a ceramic waste form that embeds Pu and radioisotopes within the ceramic form. This PEIS analyzes the impacts associated with building a new facility at any of six DOE sites (Hanford, NTS, INEL, Pantex, ORR, and SRS). As an example of a technology

variant at existing facilities (with appropriate modifications), Appendix O of this PEIS describes the can-in-canister variant at the DWPF at SRS.

- **Electrometallurgical Treatment Alternative.** This alternative would utilize electrometallurgical treatment to produce a glass-bonded zeolite (GBZ) waste form that embeds Pu and radioisotopes within the GBZ form. Although this alternative could be conducted at other sites, the Argonne National Laboratory-West (ANL-W) site at INEL was used as an example site for evaluating potential environmental effects.

In all three alternatives, surplus weapons-usable Pu would be converted to an immobilized form (glass, ceramic, or GBZ). A radiation barrier for the immobilized surplus Pu would be required for nonproliferation purposes; the radioisotopes available to produce the barrier include radioactive Cs-137 (in storage at Hanford as cesium-chloride [CsCl] capsules in shippable form) or HLW (which would only be used if an immobilization facility were located at a site with quantities of this material). HLW would not be shipped between sites, thus avoiding additional risk in transportation.⁵

Reactor Category. Under this category, surplus Pu would be converted to MOX fuel for use in domestic or Canadian reactors. Using the MOX fuel would consume a portion of the Pu content of the fuel while embedding the rest in highly radioactive spent fuel similar to that now produced by uranium-fueled commercial power reactors. The resultant spent fuel then would be stored pending disposal in accordance with the applicable spent fuel program (U.S. or Canadian).

Analyses were conducted in this PEIS on four separate MOX fuel alternatives:

- Existing LWR Alternative—utilizing existing U.S. commercial reactors that would use MOX fuel instead of traditional LEU fuel
- Partially Completed LWR Alternative—completing construction of U.S. commercial reactors that are presently maintained in an extended interim state and utilize MOX fuel in these reactors
- Evolutionary LWR Alternative—building new reactors in the United States to use MOX fuel
- CANDU Reactor Alternative—utilizing existing Canadian reactors that would use MOX fuel instead of traditional natural uranium fuel

Because the United States does not have a MOX fuel fabrication facility or capability, a dedicated facility would likely have to be constructed or an existing facility be modified at a U.S. Government or existing commercial fuel fabricator's site. In the event MOX fuel is needed before a domestic fuel fabrication plant is available, existing facilities in Europe could be used on a short-term basis to provide initial lead test assemblies and other MOX fuel.

Preferred Alternative for Pu Disposition: A combination of Reactor and Immobilization Alternatives. The Preferred Alternative calls for (1) immobilizing at least those Pu materials not readily suitable for MOX fuel using vitrification or ceramic immobilization and (2) converting pure Pu metal, including pits and oxides into MOX fuel for use in existing reactors. Use of Canadian CANDU reactors would be retained in the event a multilateral agreement is made among Russia, Canada, and the United States to implement this.

The deployment of two disposition technologies would provide increased flexibility and assurance of mission accomplishment should technical problems develop with one technology as well as greater flexibility to deal

⁵ Under the Immobilization Alternatives, DOE would not use CsCl or HLW that is a RCRA waste unless immobilization constituted sufficient RCRA treatment, or unless the CsCl or HLW first underwent RCRA treatment before immobilization with the surplus Pu.

with a wide range of Pu forms. The deployment of two technologies would signal a strong U.S. commitment to reducing the stockpiles of Pu and encourage Russia to reduce its stockpiles. The two disposition technologies that would allow an early start of Pu disposition have been determined to be the reactor and immobilization alternatives. The Preferred Alternative is a combination of reactor and immobilization alternatives.

Figure 2.1.4–1 depicts the alternative strategies and technologies for disposition of surplus Pu including the Preferred Alternative for disposition and how the material flows from the front-end process to the disposition categories.

Front-End Processes Common to Surplus Plutonium Disposition Alternatives

For the disposition of surplus Pu, a conversion process would be required to transform the various Pu forms into one suitable for further use in each of the disposition alternatives. Either pit disassembly/conversion (Section 2.4.1) or a Pu conversion process would be used (Section 2.4.2), depending on the current form of the surplus material.

Sites for the Analysis of Plutonium Disposition Alternatives

Six DOE sites and other generic and specific sites were used for assessing environmental impacts of various disposition techniques and strategies. The sites include Hanford, NTS, INEL, Pantex, ORR, and SRS. Additionally, some disposition facilities (specifically those involving the deep borehole complex, MOX fuel fabrication at a commercial facility [combination of five reactor fuel fabrication sites], and use of existing LWRs [combination of 12 existing LWRs at five sites]) have no representative sites, and so do not lend themselves to site-specific analysis at this time. Therefore, as explained more fully in Section 3.10 for the deep borehole, Section 3.11 for the MOX fuel fabrication site, and Section 3.12 for the existing LWR site, generic site characteristics have been developed for environmental evaluations of these facilities. Depending on programmatic decisions from this PEIS, DOE will conduct site-specific tiered NEPA analyses in the future. For the CANDU Reactor Alternative, a representative site (Bruce-A Nuclear Generating Station, Province of Ontario, Canada) is being considered for analysis. For the Partially Completed LWR Alternative, a representative site (Bellefonte Nuclear Plant, Alabama) is analyzed. The immobilization alternatives could be performed in new or existing, modified facilities, using technology variants identified in Table 2.4–1. For the Electrometallurgical Treatment Alternative, ANL-W at INEL is the representative site for analysis. If the Electrometallurgical Treatment Alternative is selected in the ROD, additional construction and operational impacts would result if this alternative were implemented at other sites, and additional tiered NEPA analyses and documentation would be developed. For the vitrification and ceramic immobilization alternatives, impacts of new facilities are analyzed for six DOE sites. As an example of a technology variant at an existing facility, the can-in-canister technology variant at the DWPF at SRS is described in Appendix O.

Disposition Alternatives Considered But Eliminated From Further Analysis

Twenty-seven Pu disposition options were eliminated as follows:

Radiation Barrier Alloy for Indefinite Storage. This option was eliminated because it did not have an endpoint destination comparable to options such as direct disposal, immobilization, or reactor burning. The Screening Committee noted the material (a Pu-beryllium compound) would be in a form unsuitable for a civilian HLW repository unless reconverted to remove the Pu and process it into a repository-compatible waste form.

Injection Into Continental Magma. This technology was eliminated because it is very immature. A licensing and regulatory regime for the technology is undefined and uncertain, and its use would present several ES&H concerns.

Emplacement in the Sub-Seabed. This option was eliminated because the technical approach is immature and because a licensing and regulatory regime is undefined and uncertain, which also makes the schedule uncertain. Extended operations at sea would enhance the opportunities for a transportation vessel accident in which material lost at sea could be available for retrieval. Public and international perceptions are also uncertain due to similar concerns as other ocean disposal options.

Launching to Deep Outer Space. This option was eliminated for a number of reasons. First, based on the U.S. experience to date, the risk of an explosion during launch and offsite dispersal of radioactive material would be much higher than the risks of accidents and dispersal of radioactive materials for other options. Second, if the space vehicle with its surplus fissile material payload failed to achieve orbit and reentered the atmosphere, the chances of other nations recovering the material would be enhanced and the chances of U.S. retrieval would be reduced. Also, this option would be more expensive and more time consuming to complete than many others.

Direct Immobilization With Radionuclides in Borosilicate Glass, Use of Retrofitted Defense Waste Processing Facility. This option was eliminated as unreasonable for reasons stated in the Screening Report.⁶ Installing a specially designed melter for Pu immobilization remains unreasonable. However, it is reasonable to modify the DWPF for other variants of the vitrification and ceramic immobilization alternatives.

Reactor and Accelerator Options. Five new reactor and accelerator options requiring significant technology development, including three concepts with accelerators coupled to reactors, were eliminated primarily due to their technical immaturity and the attendant costly and lengthy development and demonstration effort that would be required to bring them to viable, practical status and enable disposition options to be initiated with certainty. Although these options hold promise of higher levels of Pu destruction than other reactor burning options, these alternatives involve significant time delay, increased cost, technical uncertainties, and are not as reasonable as the mature reactor burning options to achieve the Spent Fuel Standard. However, if some of these advanced concepts are developed and successfully demonstrated or operated (for commercial nuclear power) they may be considered for Pu disposition in supplemental NEPA documents.

These five options were as follows:

- Accelerator Conversion: Molten Salt Target
- Accelerator Conversion: Particle Bed Target
- Accelerator-Driven MHR
- Particle Bed Reactor
- Molten Salt Reactor

Consuming in Modular Helium Reactors. A reactor concept was evaluated that involves MHR coupled to closed cycle power conversion systems. This option is less technically mature than other available options using MOX fuel in operating water-cooled reactor plants. The MHR would use tested, but not fully demonstrated or proved, ceramic-coated plutonium dioxide (PuO₂) fuel particles in a graphite matrix. The power conversion system would use components that have neither been tested as a "system" themselves nor integrated with a

⁶ In this option, the present DWPF at SRS would have a new, specially designed melter installed. Much of the supporting equipment would require major retrofitting for this application because DWPF was not designed for criticality control. Retrofitting the DWPF would create additional total personnel radiation exposure and would significantly interfere with its mission to stabilize and treat HLW, resulting in delays and cost escalation. Note that eliminating this "DWPF Upgrade" variant does not preclude other DWPF-related variants of the Vitrification and Ceramic Immobilization Alternatives (such as adding an adjunct melter adjacent to the DWPF, or the can-in-canister approach in the DWPF) if these other variants do not introduce increased radiation or Pu criticality concerns into the DWPF.

gas-cooled reactor system. The concept could achieve higher levels of Pu destruction than water-cooled reactors if this concept were developed and successfully operated. However, the technical uncertainty, cost, and time to develop, license, and successfully demonstrate or operate this new integrated reactor plant and power conversion system is not as reasonable as other reactor alternatives because Pu disposition can be accomplished using existing technologies. If this concept is developed and successfully demonstrated or operated for other missions, it may be considered for Pu disposition as well.

Advanced Liquid Metal Reactors with Pyroprocessing. Another reactor burning concept was evaluated that involves a variation of the integral fast reactor concept whereby an advanced liquid metal cooled reactor with a Pu alloy metal fuel would operate on a once-through cycle and then utilize pyroprocessing techniques to make a Pu-rich HLW form for potential disposal in a repository. This concept, which would use a reactor fuel cycle design still under development in a manner different from its intended purpose, would be more costly and more time-consuming than other reactor options. The development program was recently terminated by Executive and Congressional action. Since the Pu disposition can be accomplished using existing technologies, there is no justification for developing this advanced technology for the purpose of Pu disposition. However, if it is developed and successfully operated for other missions, it will be considered for Pu disposition.

Direct Emplacement (Without Immobilization) in a High-Level Waste Repository. It is highly unlikely that a determination of acceptability could be reached in a timely manner for this nonreference waste form for disposal in a HLW repository, should DOE decide to operate a HLW repository. Such a form would also require the safeguards and security requirements for weapons-usable material until the repository, currently planned to allow retrieval of spent fuel for about 100 years, is sealed.

Discard Surplus Plutonium in the Waste Isolation Pilot Plant. This option for surplus Pu would exceed capacity after meeting the needs for disposal of defense-related transuranic (TRU) waste, should DOE decide to proceed with the disposal phase of the Waste Isolation Pilot Plant (WIPP). This option would likely require amendment of the *Waste Isolation Pilot Plant Land Withdrawal Act*, associated regulations, and draft or pending regulatory compliance documents, and the planning-basis for WIPP Waste Acceptance Criteria (WAC), among other things.

Hydraulic Fracturing. This option (high-pressure injection of slurried materials into fractured shale formations) was previously tested and evaluated for civilian HLW disposal. The screening committee concluded that there was no assurance that the technical feasibility of this unproven option would be demonstrated in time for the option to be considered in the decision process. No engineered barrier would exist to prevent leakage into subsurface aquifers.

Injection of Slurry Into Deep Wells. This option, similar to the hydraulic fracturing, would not have an engineered barrier to prevent leakage into subsurface aquifers, would therefore pose unacceptable ES&H risks, and would be prohibited under current law.

Melting Into Crystalline Rock. Information previously developed in initially evaluating this approach for disposal of civilian HLW, which uses the heat from the fuel to melt into rock formations, was reviewed. It was concluded that the option is not technically viable for this disposition application because of major uncertainties. These include criticality concerns and difficulty in assuring that enough heat would be available from spent fuel (to be commingled with the surplus fissile materials) to melt the host rock.

Disposal Under Ice Caps. This option is not considered technically viable and poses unacceptable ES&H risks because ice caps in Greenland and Antarctica are not necessarily stable beyond a few hundred years. Reaching an agreement with Denmark to dispose of our nuclear materials on Greenland is not likely; a current treaty already prohibits leaving nuclear wastes in Antarctica.

Seabed Disposal and Controlled Dilution in Oceans. These options are unreasonable and were disqualified because they present ES&H concerns and are contrary to domestic and international laws, treaties, and policies. Because of increasing concerns about the pollution of marine environments with radioactive materials (ocean dumping of radioactive materials is prohibited), EPA has not issued any permits for ocean dumping or dispersal of radioactive materials in recent years. These options are inconsistent with the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, generally known as the London Dumping Convention, enacted in 1975 and amended in 1980 and 1993.

Underground Nuclear Detonation. This option is unreasonable and was disqualified because compliance with regulatory and licensing requirements is regarded as very uncertain, and compliance with ES&H regulations is unlikely for a new process of this type. In addition, the United States has a moratorium on underground nuclear testing and the President recently signed a Comprehensive Test Ban Treaty. The Screening Committee judges it unlikely that detonations for this application would be approved since such actions might undermine this national policy.

Naval Nuclear Fuel; Using Plutonium Fuel in Naval Reactor Plants. There is no design, testing, or demonstration experience with MOX fuel in naval reactors. Even if technical feasibility had been demonstrated, new classified fuel and reactor core fabrication plants would be required. Since these processes and facilities cannot be declassified, transparent confirmation of the process or final condition by international inspections would not be possible. Additionally, the number of new fuelings of naval reactor plants is so small that disposition of surplus Pu could not be accomplished in a reasonable timeframe.

Reprocessing: Using Plutonium Fuel in Existing or New Evolutionary/Advanced Light Water Reactors With Chemical Reprocessing of Spent Fuel. During reprocessing to separate Pu from spent fuel to fabricate more fuel, there are stages in the processing and handling when weapons-usable materials are more vulnerable to theft or diversion than the Stored Weapons Standard. Additionally, the time and cost required to design and construct reprocessing plants for this application are much greater than those for available, adequate options that meet the Spent Fuel Standard.

Advanced Liquid Metal Reactor With Recycle and Reuse of Metallic Alloy Fuel Elements. Based on recent DOE and Congressional action, development of the advanced liquid metal reactor/integral fast reactor concept is no longer being pursued due to a U.S. nonproliferation policy to not develop technologies that rely on Pu recycling. Since this is a relatively immature reactor concept that has not been demonstrated, and since Pu disposition can be accomplished using existing technologies, there is no justification for developing this advanced technology solely for the purpose of Pu disposition. [Text deleted.]

Glass Material Oxidation/Dissolution System. This option was eliminated due to timeliness and technical immaturity. The time required to complete the necessary R&D for this process is much longer than that for other alternatives and options.

Euratom Mixed Oxide Fuel Reactor Use. This option would involve the preparation of PuO₂ at a processing facility to be built in the United States, and transportation of the oxide to Europe where it would be fabricated into MOX reactor fuel assemblies and utilized as full-core MOX fuel loading in existing reactor facilities in one or more European countries. Final disposal of the spent fuel assemblies would be in Europe. Due to lack of capacity to complete the disposition mission, the institutional complexities such as transportation, security, and other geopolitical factors, this option was warranted unreasonable in light of the other alternatives considered.

Figure 2.1.4-2 shows the disposition options that were considered and rated based on the nine screening criteria and the principal reasons for disqualification or elimination.